

AMERICAN MUSEUM *Novitates*

PUBLISHED BY
THE AMERICAN MUSEUM
OF NATURAL HISTORY

CENTRAL PARK WEST AT 79TH STREET
NEW YORK, N.Y. 10024 U.S.A.

NUMBER 2649

APRIL 27, 1978

MARY ELLEN HARDIN

The Raccoon (*Procyon lotor*) on
St. Catherines Island, Georgia.

3. Presence of Carotenoids in Blood

AMERICAN MUSEUM *Novitates*

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK, N.Y. 10024
Number 2649, pp. 1-10, figs. 1-2, tables 1-3 April 27, 1978

The Raccoon (*Procyon lotor*) on St. Catherines Island, Georgia. 3. Presence of Carotenoids in Blood

MARY ELLEN HARDIN¹

ABSTRACT

Sixty-three blood samples were obtained by cardiac puncture from 53 raccoons from St. Catherines Island, Georgia, from January 20 to June 4, 1975 and from January 6 to 16, 1976. Blood was mixed with an equal volume of 10 percent aqueous trichloro-acetic acid to extract carotenoid pigments. The supernate was scanned with a Beckman double beam-grating spectrophotometer between wavelengths of 700 and 200 nm. Absorption maxima for carotenoids were adjusted and compared with the

following independent variables: age, sex, and weight of the raccoons, season of the year during which blood was taken, and location of capture.

All blood samples obtained from raccoons from St. Catherines Island contained carotenoids. None of the independent variables accounted for a significant amount of carotenoid variability. Further study of trace elements and environmental factors that may influence pelage color is warranted.

INTRODUCTION

Raccoons of the subspecies *Procyon lotor litoreus* are abundant on St. Catherines Island, Liberty County, Georgia. These animals are distributed throughout the Sea Islands in every habitat type (Johnson et al., 1974). Raccoons occurred in all habitats. The vegetation of the island was mapped by Somes and Ashbaugh (1973) and represents six general physiognomic types: grasslands (including tidal marshes, meadows, and upland grasslands), savanna, forest, scrub, herblands, and aquatics.

Raccoon coloration ranges from the normal brown to silver and to a reddish orange; the redder animals are said to be more common in marshes on St. Catherines Island and else-

where. Xanthochromistic pigmentation is not unique to raccoons of St. Catherines Island. Dozier (1948) reported that *P. l. maritimus* of salt marshes were pale in color and blended with marsh vegetation. The lighter color was a result of a prominent, pale subapical band of guard hairs which was exposed and projected farther beyond the underfur than it did in typical specimens of *P. l. lotor* (Dozier, Hardy and Markley, 1948). Louisiana "salt water" raccoons had reddish to red-brown hair. Bachrach (1953) speculated that this coloration was due "to the food they eat." Ivey (1948) reported northeastern Florida raccoons (*P. l. elucus*) that were light to reddish colored possibly because

¹Researcher, Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale.

of exposure to sun in treeless marshes. Thus, food and sunlight have been thought to increase xanthochromatism in raccoons.

Variations in coat color may result from at least two sets of differences in diet. Trace elements affect hair structure (copper, molybdenum, zinc) and may influence pigmentation as well (Underwood, 1956). Another explanation is that color is influenced by plant pigments ingested in food. Carotenoids are among the most widely distributed of all pigments and are a group of yellow, orange, red, or violet compounds found in both animals and plants. Animals cannot synthesize carotenoids and, therefore, must depend on their diet as a source of these compounds (Fox, 1953; Bagnara and Hadley, 1973). Ingested carotenoids impart color to numerous invertebrates and to some members of the Osteichthyes, Amphibia, Reptilia, and Aves (Fox, 1953, 1962; Needham, 1974). Little work has been done on the influence of carotenoid pigments on color of mammalian pelage. These pigments have been isolated from ovaries, eggs, liver, blood, and integument of mammals and remain unchanged from plant to animal tissue component.

Needham (1974) reported that members of the order Carnivora do not absorb carotenoids from the gut and that carotenoids are rarely found in tissues of these animals. Fox (1953) reported that "carnivorous and certain other mammals" store little or none of these pigments in fat or other tissues and contain none in their blood (Palmer, 1922; Zechmeister, 1937; Goodwin, Dewar and Gregory, 1946). However, carotenoids are found in blood plasma of some species. Here, the pigments, absorbed from the food, are in transit to places of temporary storage where they form a carotene-protein complex which is water soluble and fat insoluble. In these species, carotenes have been recovered from liver, lungs, spleen (Drummond, Gilding and MacWalter, 1934) and adrenals (Fox, 1953). See Lotze and Fleischman (1978) for other blood values.

The relative amounts of carotenoids in raccoon blood and the usefulness of certain variables in predicting levels of carotenoids was tested. The variables tested were age, sex, and weight of the animals, season of the year during which blood was taken, and location of

capture. Because the reddish color morph seemed to be concentrated in marsh areas, least distance to a marsh from each point of capture was correlated with carotenoid content to determine if reddish animals had higher carotenoid levels.

ACKNOWLEDGMENTS

I thank the members of my graduate committee, Drs. Howard J. Stains (chairman), Eugene A. LeFebvre, and Philip A. Robertson for their helpful suggestions and valuable criticisms. I also thank Dr. John H. Yopp for use of the spectrophotometer and Mr. Gary L. Nunn for assistance with the statistical analyses. Mr. Dennis M. Harman and Mr. Douglas M. Downing provided indispensable assistance with the field work. The kindness and generosity of Mr. John Toby Woods, Jr., superintendent of St. Catherines Island, are gratefully acknowledged. Finally, the continued patience and editorial comments of my husband, Jim, are gratefully appreciated.

Financial support for this project was provided through graduate assistantships from the Zoology Department of the Graduate School, Southern Illinois University; a grant-in-aid of research from the Society of the Sigma Xi; and grants from the Edward J. Noble Foundation to Dr. H. J. Stains.

STUDY AREA

St. Catherines Island forms the ocean edge of Liberty County, Georgia. The island of about 5800 hectares (14,000 acres) is near the midpoint of a sea island chain extending along the coast of northern Florida, Georgia, and southern South Carolina. St. Catherines Island is 8.2 km. (5.1 mi.) from the mainland, approximately 64.5 km. (40 mi.) southeast of Savannah, Georgia, and is 16.5 km. (10.3 mi.) long and 6.3 km. (3.9 mi., maximum) in width. (See also Hudson, 1978.)

The origin of the Sea Islands has been reviewed by Thornbury (1965), Johnson et al. (1974) and Somes and Ashbaugh (1973). St. Catherines Island was formed during the Pleistocene while vast quantities of sea water were taken up by glaciers. Dunes formed along continental beaches and remained stable while

the area flooded with sea water as the glaciers melted. These dunes were shaped by erosion and are characterized by irregular outlines, nearly level topography, and sandy sediments upon which a mature soil profile has developed. Tidal marshes developed on the landward and seaward sides of the erosion remnants during the last 5000 years and contain substantial amounts of organic material; surface elevation is near mean sea level. Beach ridges of aeolian sands formed on the seaward edge of the tidal marsh. This topography is characterized by parallel, arcuate dune ridges to 8 m. (25 ft.) and a very immature soil profile.

MATERIALS AND METHODS

In order to obtain blood samples from free-ranging raccoons, Tomahawk live-traps (255 by 305 by 760 mm.) were positioned at marked intervals of about 0.16 km. (0.1 mi.) mostly along existing roadways (fig. 1). Traps were set daily and baited with cat food or table scraps from January 20 to June 4, 1975 and from January 6 through 16, 1976. Harman trapped from January 20 to May 20, 1975. Traps were baited in late afternoon and checked routinely before 1000 hours the next morning and sometimes in late evening between 2100 and 2400 hours. Although traps were not positioned in a completely random fashion, they were in grassland, marsh edge, meadow, savanna, forest, and scrub habitats; thus they sampled all major habitats of the island.

Location of capture was recorded and then raccoons were transported to a laboratory where ketamine hydrochloride (Ketaset) was administered (0.2 cm³/kg. body weight). Ten cm³ of blood was obtained by cardiac puncture from the anesthetized animal, which was aged, sexed, weighed, and (after recovery from anesthesia within two to four hours) released at the point of capture. Two animals were held captive overnight for repeated blood sampling.

Each of the 42 whole blood samples (collected from May 20 to June 4, 1975 and from January 6 to 16, 1976) was mixed with an equal volume of 10 percent aqueous trichloro-acetic acid (TCA); TCA precipitated long chain proteins, and upon centrifugation allowed pigments and amino acids to be removed in the supernate

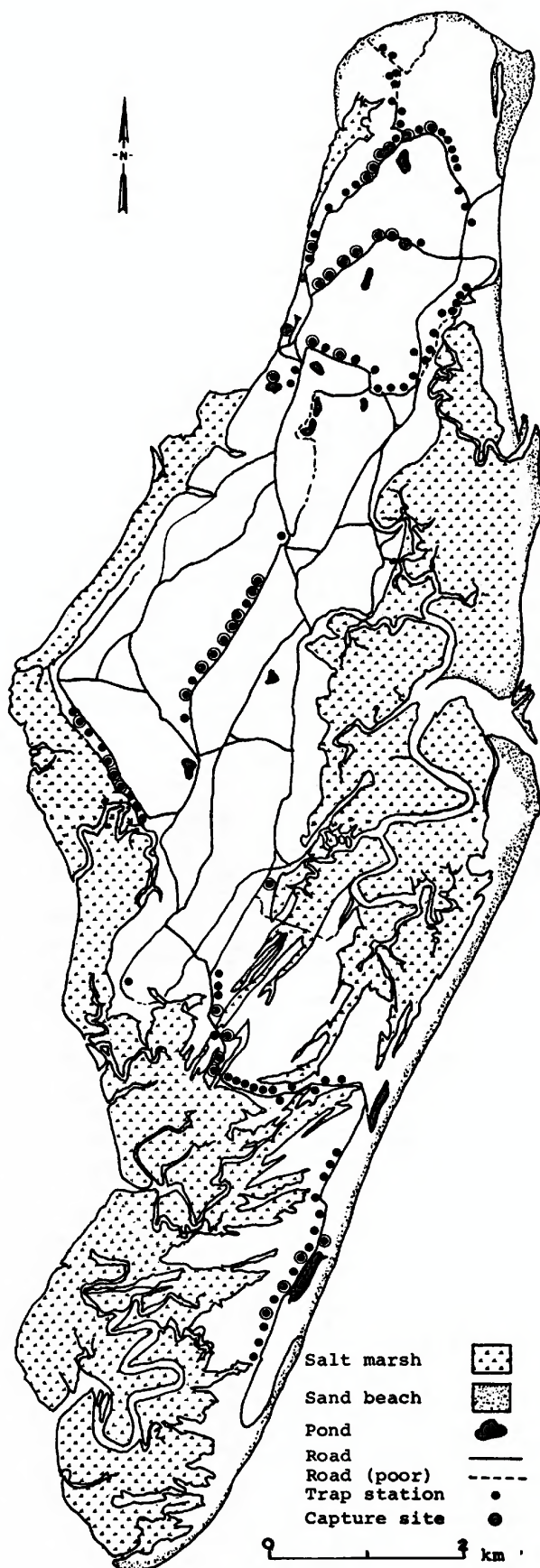


FIG. 1. Trap stations and capture locations for raccoons from St. Catherine's Island, Georgia.

(Yopp, personal commun.). The supernate from each sample was refrigerated in an airtight vial in the absence of light until analyzed. Twenty-one other whole blood samples collected by Harman (from January 21 to May 20, 1975) were frozen immediately. These were mixed with an equal volume of 10 percent TCA while thawing, centrifuged, and stored as above. Prior to analysis, samples were recentrifuged and then scanned with a Beckman double beam-grating spectrophotometer (Model DB-GT) between wavelengths of 700 and 200 nm. Absorption maxima between 390 and 395 nm., within the range of peak light absorption for carotenoids (Weast, 1976), were graphed. In order to minimize any variations in the spectrophotometer or other extrinsic factors, values were adjusted by subtracting absorbance at 700 nm. from absorbance at 390 nm., thus, no units were expressed.

Animals were aged according to total length, weight, and tooth wear as reported by Johnson (1970). Some of the animals used in this study (nos. 43 to 60, 62, 63) were prepared as whole specimens and aged by Harman using the following criteria: eye lens weight (Sanderson, 1961; Johnson, 1970), cranial suture closure (Grau, Sanderson and Rogers, 1970), epiphyseal cartilage development (Sanderson, 1961), and baculum development (Sanderson, 1950). Harman has found these techniques reliable for separating raccoons of St. Catherines Island into adult (more than two years of age), subadult (one to two years of age), and juvenile (less than one year) age classes.

Winter samples were collected from January 1 to February 28. Those collected from March 1 to June 5 were spring samples. The first of March was the mean date of the last 0°C. (32°F.) day in spring for St. Catherines Island (Environmental Data Service, 1966) and was designated the first day of spring for purposes of analysis. Least distance to a marsh was determined by plotting each capture location on a topographic map (scale 1:24000) and measuring distance to the nearest marsh.

The relationships between adjusted carotenoid content and age, sex, and weight of the raccoons, season of the year during which blood was obtained, and location of capture,

were tested by the Statistical Package for Social Sciences (SPSS) programs (Nie et al., 1975). Independent variables were coded: age (adult, subadult, juvenile), sex (0-male, 1-female), weight (kg.), season of the year (0-winter, 1-spring), and least distance to a marsh (km.). Carotenoid content of blood was designated the dependent variable. Coefficients were calculated to determine degree of correlation between all variables. Multiple regression analysis was used to determine the contribution of the independent variables to the variation in carotenoid content. Multiple regression analysis was used on first order interactions to determine if any two variables acted in conjunction to affect carotenoid level. The interaction terms were: season-age, season-sex, season-weight, season-distance, age-sex, age-weight, age-distance, sex-weight, sex-distance, and weight-distance. Higher order interactions were not calculated due to the small sample size ($n=57$).

Residuals were plotted to determine any nonlinear relationships in the data; as none was found, higher order polynomial terms were not used in the regression equation. The alpha level for all statistical tests was set at 0.05.

Attempts were made to extract carotenoids from hair of 22 St. Catherines Island raccoons. Extraction procedures were modified from Gortner (1910), Nickerson (1946), Fox (1953), and Fox and Hopkins (1965). Hair was treated with KOH and heated for 15 minutes until the hair dissolved. The heating process necessary to denature the hair proteins destroyed the carotenoids and none was recovered.

RESULTS

Of the 63 blood samples collected, those included in the statistical analyses were obtained from 14 adult males, two subadult males, three adult females, one subadult female, and nine juvenile females sampled in winter. One adult male, one subadult male, and one juvenile female were recaptured and re-sampled. The spring sampling consisted of nine adult males, seven subadult males, six adult females, and two subadult females. One adult male was recaptured and resampled. Six blood samples were not used in the statistical anal-

yses. Two (nos. 36, 39), taken in spring, were not included because sufficient information was not available to age the animals. Four samples, obtained in winter, were not used since the animals remained in the laboratory before blood was taken. These animals were either denied food (nos. 3, 21) or maintained on an artificial diet (nos. 22, 23) and will be discussed below.

All blood samples obtained from raccoons from St. Catherines Island contained carotenoids; adjusted levels ranged from 0.020 to 1.612 (table 2). The mean level was 0.329 (s.d.=0.257, $n=57$). Correlations between carotenoid content and adult, subadult, and juvenile age classes, sex, weight, season, and location of capture are shown in table 1. These results, which were statistically nonsignificant, indicated only a weak relationship between carotenoid content and the independent variables.

Multiple regression analysis yielded R^2 values for each of the independent variables (table 3). Age, sex, weight, season, and location of capture accounted for 14.8 percent of the variability in carotenoid level. This regression analysis did not reveal any of the independent variables contributing a statistically significant amount to carotenoid variability.

First order interactions alone accounted for 11.2 percent of the carotenoid variability (table 3); none of the interactions was significant. Season-juvenile and juvenile-sex interactions were not calculated because of perfect correlations ($r=1.0$) in these categories, as all juveniles were female and captured in winter. Residual scores were plotted; values seemed to be randomly distributed, and, therefore, no curvilinear relationships were suggested (fig. 2).

DISCUSSION

Raccoons of St. Catherines Island have carotenoids in their blood, contrary to reports that carotenoids rarely are found in tissues of members of the Carnivora (Fox, 1953; Needham, 1974). Relative amounts of carotenoids ranged from 0.02 to more than 80 times that value and were not affected by age, sex, weight of the animal, season during which blood was obtained, or location of capture.

The variables tested did not interact to affect

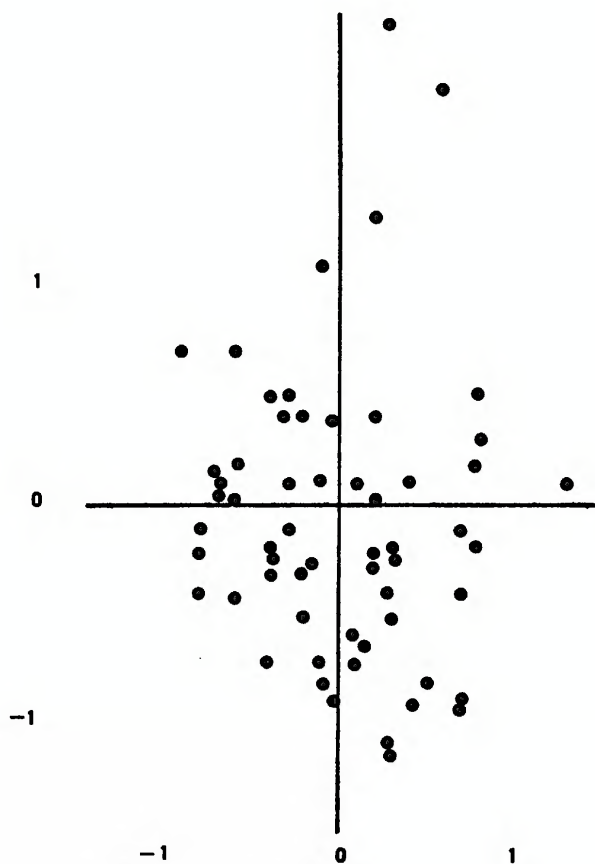


FIG. 2. Distribution of residual values of predicted carotenoid content from raccoons from St. Catherines Island, Georgia; x axis is predicted standardized dependent variable, y axis is standardized residual.

nor account for a significant amount of carotenoid variability. Significant correlations were expected between weights of animals and their age, sex, and season of the year based on Stains (1956), Johnson (1970), and previous literature on the natural history of raccoons. Other significant results indicated more subadults were captured in spring and most of the adult raccoons captured were male. Since all juvenile animals sampled were females captured in winter, a significant relationship was found between juvenile age class and sex, and season.

Female raccoons failed to show higher carotenoid levels than males. Among the various species of vertebrates and invertebrates studied, females generally had greater carotene con-

TABLE 1
Correlation Coefficients Between Selected Data from Raccoons from St. Catherines Island, Georgia

| | Season | Adult | Subadult | Juvenile | Sex | Weight | Distance | Carotene |
|----------|--------|-------|---------------------|---------------------|---------------------|---------------------|----------|----------|
| Season | — | 0.078 | 0.278 ^a | -0.408 ^a | -0.120 | -0.292 ^a | 0.234 | -0.166 |
| Adult | — | — | -0.661 ^a | -0.561 ^a | -0.303 ^a | 0.624 ^a | 0.003 | 0.037 |
| Subadult | — | — | — | -0.251 | -0.173 | -0.328 ^a | 0.033 | -0.056 |
| Juvenile | — | — | — | — | 0.582 ^a | -0.443 ^a | -0.041 | 0.014 |
| Sex | — | — | — | — | — | -0.668 ^a | 0.019 | -0.006 |
| Weight | — | — | — | — | — | — | -0.110 | -0.036 |
| Distance | — | — | — | — | — | — | — | -0.234 |

^aSignificant at 0.05.

TABLE 2
Selected Data from Raccoons of St. Catherines Island, Georgia

| Specimen Number | Eartag Number | Season ^a Year | Age | Sex | Weight (kg.) | Distance (km.) | Carotene Content |
|-----------------|---------------|-----------------------------|------|-----|-----------------|-------------------|---------------------|
| 1 | GA001 | W 1976 | Adul | M | 5.1 | 0.05 | 0.161 |
| 2 | 237 | W 1976 | Adul | M | 5.1 | 1.40 | 0.245 |
| 3 | 237 | W 1976 | Adul | M | 5.1 | Held | 0.195 |
| 4 | 245 | W 1976 | Adul | M | 5.6 | 0.25 | 0.110 |
| 5 | 249 | W 1976 | Adul | F | 3.3 | 1.10 | 0.310 |
| 6 | 261 | W 1976 | Adul | M | 4.8 | 0.05 | 0.340 |
| 7 | 298 | W 1976 | Suba | M | 3.6 | 0.90 | 0.181 |
| 8 | 298 | W 1976 | Suba | M | 3.4 | 0.65 | 0.368 |
| 9 | 311 | W 1976 | Adul | M | 5.7 | 0.40 | 0.102 |
| 10 | 504 | W 1976 | Adul | M | 5.8 | 0.75 | 0.208 |
| 11 | 609 | W 1976 | Adul | M | 5.2 | 0.70 | 1.612 |
| 12 | 609 | W 1976 | Adul | M | 4.9 | 0.65 | 0.125 |
| 13 | 616 | W 1976 | Juve | F | 2.8 | 0.80 | 0.352 |
| 14 | 616 | W 1976 | Juve | F | 2.8 | 0.80 | 0.045 |
| 15 | 617 | W 1976 | Juve | F | 2.6 | 0.80 | 0.272 |
| 16 | 618 | W 1976 | Juve | F | 2.5 | 0.80 | 0.380 |
| 17 | 619 | W 1976 | Juve | F | 2.0 | 0.05 | 0.412 |
| 18 | 620 | W 1976 | Juve | F | 2.2 | 1.10 | 0.356 |
| 19 | 621 | W 1976 | Juve | F | 3.0 | 0.05 | 0.110 |
| 20 | 622 | W 1976 | Adul | M | 5.9 | 0.35 | 0.320 |
| 21 | 622 | W 1976 | Adul | M | 5.6 | Held | 0.241 |
| 22 | 622 | W 1976 | Adul | M | | Held | 0.361 |
| 23 | 622 | W 1976 | Adul | M | 5.3 | Held | 0.400 |
| 24 | 623 | W 1976 | Juve | F | 2.2 | 0.05 | 0.962 |
| 25 | 624 | W 1976 | Juve | F | 2.2 | 0.70 | 0.185 |
| 26 | 625 | W 1976 | Adul | M | 5.0 | 0.05 | 0.378 |
| 27 | 628 | W 1976 | Adul | M | 5.5 | 0.05 | 0.585 |
| 28 | DH646 | W 1976 | Adul | M | 3.4 | 1.10 | 0.482 |
| 29 | DH647 | W 1976 | Adul | F | 3.0 | 0.05 | 0.688 |
| 30 | 237 | S 1975 | Adul | M | 4.2 | 1.00 | 0.238 |
| 31 | 237 | S 1975 | Adul | M | 3.8 | 0.85 | 0.210 |
| 32 | 245 | S 1975 | Adul | M | 3.7 | 0.60 | 0.299 |
| 33 | 291 | S 1975 | Suba | M | 3.4 | 0.85 | 0.170 |
| 34 | 338 | S 1975 | Suba | F | 2.1 | 1.00 | 0.167 |

TABLE 2 — (Continued)

| Specimen Number | Eartag Number | Season ^a Year | Age | Sex | Weight (kg.) | Distance (km.) | Carotene Content |
|-----------------|---------------|-----------------------------|------|-----|-----------------|-------------------|---------------------|
| 35 | 340 | S 1975 | Suba | M | 2.0 | 1.65 | 0.632 |
| 36 | 540 | S 1975 | | M | | 0.70 | 0.275 |
| 37 | 577 | S 1975 | Adul | M | 3.7 | 1.35 | 0.020 |
| 38 | 579 | S 1975 | Suba | F | 2.4 | 0.80 | 0.367/ |
| 39 | 585 | S 1975 | | M | | 0.05 | 1.032 |
| 40 | 586 | S 1975 | Adul | F | 2.5 | 0.85 | 0.269 |
| 41 | 587 | S 1975 | Suba | M | 3.4 | 0.10 | 0.173 |
| 42 | 588 | S 1975 | Adul | M | 2.7 | 1.00 | 0.472 |
| 43 | DH291 | W 1975 | Adul | M | 4.7 | 0.01 | 0.120 |
| 44 | DH292 | W 1975 | Suba | M | 3.8 | 1.00 | 0.150 |
| 45 | DH293 | W 1975 | Suba | F | 2.2 | 0.30 | 0.348 |
| 46 | DH328 | W 1975 | Adul | M | 4.6 | 0.40 | 0.462 |
| 47 | DH334 | W 1975 | Adul | F | 2.7 | 0.40 | 0.664 |
| 48 | DH335 | W 1975 | Juve | F | 1.7 | 0.35 | 0.289 |
| 49 | DH342 | W 1975 | Adul | M | 4.8 | 0.01 | 0.390 |
| 50 | DH343 | S 1975 | Adul | M | 4.1 | 1.15 | 0.156 |
| 51 | DH371 | S 1975 | Adul | F | 2.6 | 0.80 | 0.105 |
| 52 | DH372 | S 1975 | Adul | F | 2.7 | 0.80 | 0.082 |
| 53 | DH388 | S 1975 | Suba | M | 2.1 | 0.20 | 0.590 |
| 54 | DH390 | S 1975 | Adul | F | 2.5 | 0.35 | 0.283 |
| 55 | DH394 | S 1975 | Adul | M | 4.7 | 0.75 | 0.071 |
| 56 | DH404 | S 1975 | Suba | M | 2.8 | 0.40 | 0.435 |
| 57 | DH421 | S 1975 | Suba | M | 2.9 | 1.00 | 0.152 |
| 58 | DH430 | S 1975 | Adul | M | 4.1 | 0.42 | 0.700 |
| 59 | DH431 | S 1975 | Adul | F | 2.2 | 0.35 | 0.357 |
| 60 | DH487 | S 1975 | Adul | M | 3.9 | 0.10 | 0.480 |
| 61 | DH497 | S 1975 | Adul | F | 3.6 | 0.75 | 0.179 |
| 62 | DH516 | S 1975 | Adul | M | 3.7 | 1.00 | 0.207 |
| 63 | DH519 | S 1975 | Suba | M | 2.5 | 0.05 | 0.199 |

^aSeason during which blood sample was taken; W=winter, S=spring.

centrations than males (Fox, 1953; Henry, 1964; Needham, 1974). For example, female crabs at maturity have four times as much fat as males. Since fats act as a depository for carotenoids, this may allow female crabs to deposit more carotenes (Needham, 1974). Among mammals, the plasma of cows contains three to five times the amount found in the plasma of bulls (Semb, Baumann and Steenbock, 1934). In humans also, values for women may be slightly higher than those for men (Henry, 1964). I expected that female raccoons would have higher carotenoid levels during the late winter and early spring breeding season (McKeever, 1958) as corpora lutea, clostrum, and milk contain large amounts of these pigments (Fox, 1953).

Weights of sampled raccoons ranged from 1.7 to 5.9 kg. (3.8-13.0 lbs.). Many animals trapped in the winter of 1975 and early spring of 1975 appeared thin and weak. Several were captured by hand and, upon necropsy, showed little or no subcutaneous fat; some had heavy intestinal helminth infestations (Harman, personal commun.). These animals exhibited symptoms of canine distemper as described by Menges, Habermann and Stains, (1955) and Johnson (1970) and probably weighed less than healthy animals. A "bumper" acorn crop in the fall of 1975 (J. T. Woods, Jr., personal commun.) may have allowed heavier raccoons in the winter of 1976, as necropsy showed thick subcutaneous fat deposits.

Although sick animals did not show consis-

TABLE 3
Results of Multiple Regression Analysis on
Selected Data and First Order Interactions from
Selected Data from Raccoons from
St. Catherines Island, Georgia

| Variable | R ² Value |
|---------------------|----------------------|
| Adult age class | 0.05236 |
| Subadult age class | 0.00085 |
| Juvenile age class | 0 |
| Sex | 0.00070 |
| Weight | 0.02573 |
| Season | 0.02768 |
| Distance from marsh | 0.04072 |
| Season-adult | 0.02274 |
| Season-subadult | 0 |
| Season-juvenile | NA |
| Season-sex | 0.00514 |
| Season-weight | 0.00069 |
| Season-distance | 0.01031 |
| Adult-sex | 0.01065 |
| Adult-weight | 0.00893 |
| Adult-distance | 0.00029 |
| Subadult-sex | 0 |
| Subadult-weight | 0.00017 |
| Subadult-distance | 0.03419 |
| Juvenile-sex | NA |
| Juvenile-weight | 0 |
| Juvenile-distance | 0 |
| Sex-weight | 0.00115 |
| Sex-distance | 0.01699 |
| Weight-distance | 0.00095 |
| Total | 0.26024 |

tently low carotenoid levels, analysis of carotenoid content in raccoons may represent a reliable method for assessing nutritional condition. For example, carotenoid level in humans is correlated closely with dietary intake and provides an index of fat digestion, as well as fat absorption (Levinson and MacFate, 1969; Searcy, 1969). Carotene-poor fodder in cows causes a great decrease in milk carotenes, particularly in butterfat which becomes colorless (Lundberg, 1931). Pierce (1945) reported that sheep require 50-55 μg of carotene/kg. body weight/day to satisfy Vitamin A requirements and avoid avitaminosis. Carotenes are precursors to Vitamin A which is an important growth factor, source of visual pigments, and

essential for normal structure and behavior of epithelial tissue (Searcy, 1969).

Raccoons that remained at the laboratory and were denied food and water showed a decline in carotenoid content (nos. 2, 3; 20, 21). Sample numbers 22 and 23, taken after the animal had been given water, cat food, and an egg, showed an increase in carotenoid content (table 2). Human daily variations in carotenoid content may be up to ± 50 percent and reflect dietary intake (Henry, 1964). However, Searcy (1969) reported that single meals have little effect on carotene or serum Vitamin A concentration in humans. Further experimentation is warranted to determine if single feeding sessions influence serum carotene levels in raccoons.

Calculation of correlation coefficients revealed only nonsignificant relationships between carotenoid content and the variables tested. Location of capture and carotenoid content appeared to be somewhat related, indicating animals captured near marshes tended to have higher carotenoid levels. These higher levels may have been due to certain food items (plants, animal prey) available or more abundant in the marshes. However, reddish animals from marsh areas did not consistently show higher carotenoid levels than nonreddish animals from marsh areas. Other elements in the diet may affect the pelage color and full investigation of these, as well as environmental factors, is warranted.

LITERATURE CITED

- Bachrach, Max
1953. *Fur, a practical treatise*. 3rd ed. New York, Prentice-Hall, Inc., pp. 1-660.
- Bagnara, Joseph T., and Mac E. Hadley
1973. *Chromatophores and color change; the comparative physiology of animal pigmentation*. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., pp. 1-202.
- Dozier, Herbert L.
1948. A new eastern marsh-inhabiting race of raccoon. *Jour. Mammal.*, vol. 29, no. 3, pp. 286-290.
- Dozier, Herbert L., Thora M. P. Hardy, and Merle H. Markley
1948. *Fur characteristics of two eastern rac-*

- coons. Jour Mammal., vol. 29, no. 4, pp. 383-393.
- Drummond, J. C., H. P. Gilding, and R. J. Mac-Walter
1934. Fate of carotene introduced into the circulation. Jour. Physiol., vol. 82, no. 1, pp. 75-78.
- Environmental Data Service
1966. Selected climatic maps of the United States. U. S. Dept. of Commerce, Environmental Science Services Administration, pp. 1-32.
- Fox, Denis L.
1953. Animal biochromes and structural colours; physical, chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.
1962. Carotenoids of the scarlet ibis. Comp. Biochem. Physiol., vol. 5, no. 1, pp. 31-43.
- Fox, Denis L., and Thomas S. Hopkins
1965. Exceptional carotenoid metabolism in the Andean flamingo. Nature, vol. 206, no. 4981, pp. 301-302.
- Goodwin, T. W., A. D. Dewar, and R. A. Gregory
1946. The transport of absorbed carotene in Herbivora. In Fox, Denis L., 1953, p. 173, Animal biochromes and structural colours; physical, chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.
- Gortner, Ross A.
1910. Studies on melanin. I. Methods of isolation. The effect of alkali on melanin. Jour. Biol. Chem., vol. 8, pp. 341-363.
- Grau, Gerald A., Glen C. Sanderson, and John P. Rogers
1970. Age determination of raccoons. Jour. Wildlife Management, vol. 34, no. 2, pp. 364-372.
- Henry, Richard J.
1964. Clinical chemistry, principles and techniques. New York, Harper and Row, pp. 1-1128.
- Hudson, Edwin
1978. The raccoon (*Procyon lotor*) on St. Catherines Island, Georgia. 2. Relative abundance in different forest types as a function of population density. Amer. Mus. Novitates, no. 2648, pp. 1-15.
- Ivey, R. De Witt
1948. The raccoon in the salt marshes of north-eastern Florida. Jour. Mammal., vol. 29, no. 3, pp. 290-291.
- Johnson, A. Sydney
1970. Biology of the raccoon (*Procyon lotor varius* Nelson and Goldman) in Alabama. Auburn Univ. Agric. Exp. Station Bull. No. 402, pp. 1-148.
- Johnson A. Sydney, Hilburn O. Hillestad, Sheryl F. Shanholtzer, and G. Frederick Shanholtzer
1974. An ecological survey of the coastal region of Georgia. Natl. Park Service Sci. Monogr. Ser. No. 3, pp. 1-233.
- Levinson, Samuel A., and Robert P. MacFate
1969. Clinical laboratory diagnosis. Philadelphia, Lea and Febiger, pp. 1-1323.
- Lotze, Jorge-Henner, and Allan I. Fleischman
1978. The raccoon (*Procyon lotor*) on St. Catherines Island, Georgia. 1. Biochemical parameters of urine and blood serum. Amer. Mus. Novitates, no. 2644, pp. 1-5.
- Lundberg, M.
1931. The pigments of milk. In Fox, Denis L., 1953, pp. 174-175, Animal biochromes and structural colours; physical, chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.
- McKeever, Sturgis
1958. Reproduction in the raccoon in the south-eastern United States. Jour. Wildlife Management, vol. 22, no. 2, p. 211.
- Menges, Robert W., Robert T. Habermann, and Howard J. Stains
1955. A distemper-like disease in raccoons and isolation of *Histoplasma capsulatum* and *Haplosporangium parvum*. Trans. Kansas Acad. Sci., vol. 58, no. 1, pp. 58-67.
- Needham, Arthur E.
1974. The significance of zoochromes. New York, Heidelberg, Berlin, Springer-Verlag, pp. 1-429.
- Nickerson, Mark
1946. Relation between black and red melanin in feathers. Physiol. Zool., vol. 19, no. 1, pp. 66-77.
- Nie, Norman H., C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale H. Bent
1975. Statistical package for the social sciences. 2nd ed. New York, McGraw Hill, pp. 1-675.
- Palmer, L. S.
1922. Carotinoids and related pigments. In Fox, Denis L., 1953, pp. 173-174, Animal biochromes and structural colours; physical,

- chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.
- Pierce, A. W.
1945. The effect of intake of carotene on the general health and on the concentration of carotene and of vitamin A in the blood and liver of the sheep. *In* Fox, Denis L., 1953, p. 177, Animal biochromes and structural colours; physical, chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.
- Sanderson, Glen C.
1950. Methods of measuring productivity in raccoons. *Jour. Wildlife Management*, vol. 14, no. 4, pp. 389-402.
1961. The lens as an indicator of age in the raccoon. *American Midland Nat.*, vol. 65, no. 2, pp. 481-485.
- Searcy, Ronald L.
1969. *Diagnostic biochemistry*. New York, McGraw-Hill, pp. 1-660.
- Semb, J., C. A. Baumann, and H. Steenbock
1934. Fat-soluble vitamins. XLI. The carotene and vitamin A content of clostrum. *Jour. Biol. Chem.*, vol. 107, pp. 697-703.
- Somes, Horace A., Jr., and Thomas R. Ashbaugh
1973. Vegetation of St. Catherines Island, Georgia. Devon, Pennsylvania, Jack McCormick and Assoc., pp. 1-47.
- Stains, Howard J.
1956. The raccoon in Kansas, natural history, management, and economic importance. *Univ. Kansas Mus. Nat. Hist. and State Biol. Survey, Misc. Publ. No. 10*, pp. 1-76.
- Thornbury, William D.
1965. *Regional geomorphology of the United States*. New York, John Wiley and Sons, Inc., pp. 1-609.
- Underwood, Eric J.
1956. *Trace elements*. New York, Academic Press, pp. 1-430.
- Weast, Robert C., ed.
1976. *Handbook of chemistry and physics*. 57th edition, Cleveland, Ohio, CRC Press, p. C-241.
- Zechmeister, L.
1937. Die Carotinoide im tierischen Stoffwechsel. *In* Fox, Denis L., 1953, pp. 173-174, Animal biochromes and structural colours; physical, chemical, distributional and physiological features of coloured bodies in the animal world. Cambridge, University Press, pp. 1-378.

